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COMPARISON OF THE CARBONIFEROUS AND PER-  
MIAN FORMATIONS OF NEBRASKA AND KANSAS.

INTRODUCTION.

AFTER having devoted three summers to the study of the Upper Carboniferous and Permian formations of Kansas, the writer recently reviewed quite rapidly the similar formations of southeastern Nebraska, and in this paper will give an outline of their general correlation.

No particular formation was traced from Kansas into or across Nebraska, nor were the stratigraphic details worked out carefully in Nebraska; still the work done, limited as it was in character, showed the geologic age and general relation of the rocks of Kansas to those of Nebraska, and as various opinions are entertained regarding these relations it seems important to give a brief description of this work.

NEMAHA COUNTY.

*Wabaunsee formation.*—It is desirable to select the three counties—Nemaha, Otoe, and Cass—in which the greater part of the field work was done, for the general subdivisions of this paper and then under each county to describe its geologic formations, beginning with the oldest.

The exposures in the eastern part of Nemaha county along the Missouri River were very fully described by Meek,<sup>1</sup> sections

<sup>1</sup>Final Rep. U. S. Geol. Sur. Nebraska and adjacent Territories, Pt. II, Paleontology, pp. 109-114.

were given, together with lists of fossils from the vicinity of the towns, Peru, Brownville, and Aspinwall,<sup>1</sup> and the following species were reported by him from these localities:

1. *Neuropteris hirsuta* Lesqx.
2. *Neuropteris Loschii* Brgt.
3. *Fusulina cylindrica* Fischer.
4. *Productus nebrascensis* Owen.
5. *Productus semireticulatus* (Martin) de Kon.
6. *Derbya crassa* (M. & H.) Hall & Clarke.
7. *Meekella striato-costata* (Cox) White & St. John.
8. *Spirifer cameratus* Morton.
9. *Spirifer (Martinia) plano-convexus* Shum.
10. *Spiriferina kentuckensis* Shum.
11. *Athyris (Seminula) subtilita* (Hall) Newb.
12. *Nuculana bellistriata* (Stevens) Meek.
13. *Myalina perattenuata* M. & W.
14. *Aviculopecten Whitei* Meek.
15. *Edmondia aspinwallensis* Meek.
16. *Allorisma subcuneatum* M. & H.
17. *Bellerophon percarinatus* Con.
18. *Straparollus (Euomphalus) catilloides* (Con.) Keyes = *Euomphalus rugosus* Hall.
19. *Nautilus occidentalis* Swallow.
20. *Deltodus (?) angularis* N. & W.
21. *Productus longispinus* Sowb. = Nor. & Pratt.
22. *Chonetes granulifera* Owen.
23. *Bellerophon carbonarius* Cox.
24. *Bellerophon Montfortianus* Nor. & Pratt.
25. *Productus pertenuis* Meek.
26. *Productus cora* d'Orbigny.
27. *Myalina subquadrata* Shum.
28. *Aviculopecten occidentalis* (Shum) M. & W.

The fossils of the above list are nearly all well-known Carboniferous species as was stated by Meek.<sup>2</sup>

Marcou referred the rocks along the Missouri River in this county to the Dyas<sup>3</sup> (= Permian) but this view was thoroughly

<sup>1</sup> Fin. Rep. U. S. Geol. Sur. Nebraska, etc., pp. 109, 110, 112, and the "Tabular list, illustrating the geological and geographical range of the fossils of eastern Nebraska," pp. 124-127.

<sup>2</sup> *Ibid.*, p. 114.

<sup>3</sup> Bull. Soc. Géol. France, 2<sup>e</sup> série, t. XXI, 1864, p. 134.

disproved by Meek, who criticised Professor Marcou's correlation in the following words: "but upon what evidence he [Professor Marcou] does not say, nor is it apparent to anyone who regards fossils as any guide in identifying rocks, as those found here consist of the same forms constituting the group so often mentioned as characterizing the Coal Measures of the Western States."<sup>1</sup>

Meek regarded the exposures along the Missouri River in Nemaha county as geologically above the Nebraska City beds, for he said: "At Nebraska City, and below there, at Otoe City, Brownville, and Aspinwall, there are, perhaps, altogether, near 150 to 200 feet of additional strata, all holding probably a position above the geological horizon of the top of the boring at Nebraska City."<sup>2</sup> On the contrary, Dr. Hayden regarded the Aspinwall section as somewhat older than that at Nebraska City, for he said: "The rocks at Aspinwall are all geologically at a little lower horizon than the Nebraska City beds, and mostly beneath the Brownville beds."<sup>3</sup> In the Aspinwall section Meek reported a stratum of coal one foot ten inches in thickness, eighteen feet above low water of the Missouri River and another six-inch stratum eleven and one-half feet higher. No opportunity was afforded me to study this section, hence I am unable to state whether the coal lies at the base of the Wabaunsee formation or not; but all the rocks of this county exhibited along the bluffs of the Missouri River belong to that geologic series usually termed the Upper Coal Measures, for which Dr. Keyes has proposed the very appropriate name of Missourian.<sup>4</sup>

<sup>1</sup> Fin. Rep. U. S. Geol. Sur. Nebraska, etc., p. 114.

<sup>2</sup> *Ibid.*, p. 137; also see p. 123, where a similar statement occurs.

<sup>3</sup> *Ibid.*, p. 17.

<sup>4</sup> Am. Geol., Vol. XVIII, July 1896, p. 25; also see Iowa Geol. Surv., Vol. I, 1893, p. 85. The writer would suggest the following classification for the Upper Coal Measures of the Western Interior province:

Missourian series (Keyes),	-	-	-	{	Cottonwood formation (Prosser)
					Wabaunsee " "
					_____ " "

The formations below the Wabaunsee have been recently studied by Drs. Keyes and Haworth, to whom the writer leaves the selection of names for the lower part of the series.

With the exception of the region adjacent to the Missouri River, the geology of Nemaha county was not described by Meek or Hayden.

About twelve miles northwest of Aspinwall and some 235 feet above Nemaha City, which is near the level of the Missouri River, and near the center of Nemaha county, is Auburn, the county seat. To a large extent, the rocks of this region are concealed by the thick deposit of loess, but there are occasional exposures along the streams or at favorable places on the bluffs or hills. In the vicinity of Auburn are a few outcrops of rocks which are referred to the upper part of the Wabaunsee formation. Along the highway, one and one-fourth miles directly west of Auburn, the rocks show for a short distance. The top of the outcrop is some thirty-five feet higher than the Auburn hotel, or approximately 270 feet above the Missouri River, and is just west of the Sheridan cemetery on the east side of the South Fork of the Nemaha River. The following beds occur in descending order:

	Feet
5. Rough yellowish limestone - - - - -	1 = 65
4. Soft light gray to yellowish shales - - - - -	2 = 64
3. Drab hard limestone that weathers to a light gray color. A few fossils— <i>Aviculopecten occidentalis</i> (Shum.) M. & W. and fragments of other species - - - - -	2 = 62
2. Light gray and greenish shales, the lowest very white . . . . .	} 60 = 60
1. Covered to the level of South Fork of the Nemaha River - - - .	

These rocks are considered to belong in the upper part of the Wabaunsee formation; for on the upland two and one-half miles farther west and perhaps fifty feet higher is a ledge of light gray limestone composed to a considerable extent of specimens of *Fusulina cylindrica* Fischer which the author regards as the Cottonwood limestone of Kansas. There are a number of outcrops and quarries of this limestone on the upland in the western central part of Nemaha county, as well as a few exposures of the underlying rocks, but as they are only a few miles northwest of this eastern outcrop of the Cottonwood limestone they may be described in connection with it.

*Cottonwood formation.*—The most eastern outcrop of the Cottonwood limestone seen in Nemaha county is the one which is known as the Van Court or Keyes quarry and is three and three-fourth miles directly west of Auburn. Unfortunately my barometer at the time of my visit was not reading accurately; but its altitude is estimated as some 345 feet above the Missouri River. The Cottonwood limestone forms a massive light gray stratum four feet thick, moderately hard and filled with large numbers of *Fusulina*. When freshly broken the *Fusulinas* though slightly darker in color than the limestone are less prominent than on the weathered surface and are only conspicuous when seen through a magnifying glass. On the weathered surface of the rock the shells resist decay longer than the limestone and stand out prominently. One who has visited the large quarries of Cottonwood limestone in northern and central Kansas would be immediately impressed with this very striking similarity. Few, if any, fossils other than *Fusulina cylindrica* Fischer occur in this limestone; only an occasional fragment of a spine of *Archæocidaris* or a bit of shell was noticed. The section at the Keyes quarry is as follows:

	Ft.	In.	Ft.	In.
3. Shaly limestone containing <i>Athyris</i> ( <i>Seminula</i> ) <i>subtilita</i> (Hall) Newb. and a few other fossils	-	-	-	-
	1	=	6	9
2. Light gray shales to shaly limestone	-	-	-	-
	1	9	=	5 9
1. <i>Cottonwood limestone</i> , light gray massive <i>Fusulina</i> limestone	4	=	4	

The *Nemaha county quarry* which is the most extensively worked is the next well-exposed section of the Cottonwood limestone and is one and one-fourth miles west of the Keyes quarry. It is located by the side of the Burlington and Missouri River Railroad, five miles due west of Auburn and one mile north of Hickory Grove. The average of three barometric readings makes the bottom of the quarry 130 feet higher than Auburn or approximately 365 feet above the Missouri River. This is twenty feet higher than the base of the Keyes quarry which gives a dip directly east of twenty feet in one and one-fourth miles or at the rate of sixteen feet per mile. The follow-

ing section of the Nemaha county quarry gives a clear idea of the character of the Cottonwood limestone and associated rocks as they appear in Nebraska.

SECTION OF THE NEMAHA COUNTY QUARRY.

		Ft.	In.		Ft.	In.
5.	Soil - - - - -	3		=	12	10
4.	Somewhat shaly light gray limestone used for riprap. Fossils common, especially <i>Athyris</i> ( <i>Seminula</i> ) <i>subtilita</i> (Hall) Newb. - - - - -	2	10	=	9	10
3.	Light gray shaly limestone changing to shales on weathered surface, used for railroad ballast. From 1 foot 1 inch to 1 foot 9 inches in thickness. Fossils not so common as in upper limestone - - - - -	1	9	=		7
2.	Cottonwood limestone, of light gray color, containing immense numbers of <i>Fusulina cylindrica</i> Fischer. In two layers, the upper 2 feet and the lower 1 foot thick, 3			=	5	3
1.	Light gray to slightly yellowish limestone, which contains some almost white streaks and in places is bluish in color. Very few specimens of <i>Fusulina</i> . Bottom of the quarry - - - - -	2	3	=	2	3

As stated above, No. 2 of the section contains immense numbers of *Fusulina cylindrica* Fischer with an occasional broken spine of *Archæocidaris* sp.; while in No. 1 there are very few specimens of *Fusulina*. This character agrees with the Cottonwood limestone at its typical localities in Kansas where the *Fusulinas* are only found abundantly in the upper part of the limestone. On this account it seems advisable to the writer to regard both Nos. 1 and 2 as representing the Cottonwood limestone of Kansas which will give it a thickness of five feet three inches in the Nemaha county quarry. The shaly limestones and shales above the Cottonwood limestone—Nos. 3 and 4 of the section—contain a moderate number of fossils although none of the species are abundant. The following were collected:

*Athyris* (*Seminula*) *subtilita* (Hall) Newb.=*A. argentea* (Shep.) Keyes (c).<sup>1</sup>

*Productus semireticulatus* (Mart.) de Kon. (c).

<sup>1</sup> The relative abundance of the species is indicated in the following manner:

*Derbya crassa* (M. & H.) H. & C. (rr).

*Pinna peracuta* Shum. (?) only a fragment (rr).

*Allorisma* sp. fragment of an impression (rr).

*Archæocidaris* sp. fragment of spines (r).

Above the Cottonwood limestone in northern and central Kansas are about fourteen feet of yellowish, calcareous shales, the lower seven feet of which contain abundant fossils. In Nebraska no similar shales have been found above the Cottonwood shales. Perhaps the shaly limestones and shales—Nos. 3 and 4 of the above section—represent the Cottonwood shales, although the fossils are not nearly as abundant. If this supposition be correct, then they belong in the Cottonwood formation. Again it is possible that the Cottonwood shales are represented by the thin shale or shaly limestone, No. 3, which is between one and two feet in thickness; while No. 4 represents the shaly limestones at the base of the Neosho formation in Kansas.<sup>1</sup>

The *Gilbert quarry* region is six miles west and two and one-fourth miles north of Auburn or about two and one-half miles northwest of the Nemaha county quarry. Near the head of a small stream and by the highway are several quarries. One on the east side of the highway, just south of the Gilbert quarry, gives the following section:

	Feet	Feet
5. Coarse grayish shales to rather shaly gray limestone at the base - - - - -	3	= 10¾
4. Massive gray limestone, fragments of fossils numerous (2 feet in Gilbert quarry) - - - - -	1½	= 7¾
3. Rather coarse, grayish shales (shaly limestone in Gilbert quarry) - - - - -	1¼	= 6¼
2. <i>Cottonwood</i> limestone, massive <i>Fusulina</i> limestone with small amount of flint and an occasional <i>crinoid</i> segment, and fragment of <i>Athyris</i> - - - - -	3½	= 5
1. Grayish to slightly buff limestone without <i>Fusulinas</i> . Bottom of quarry - - - - -	1½	= 1½

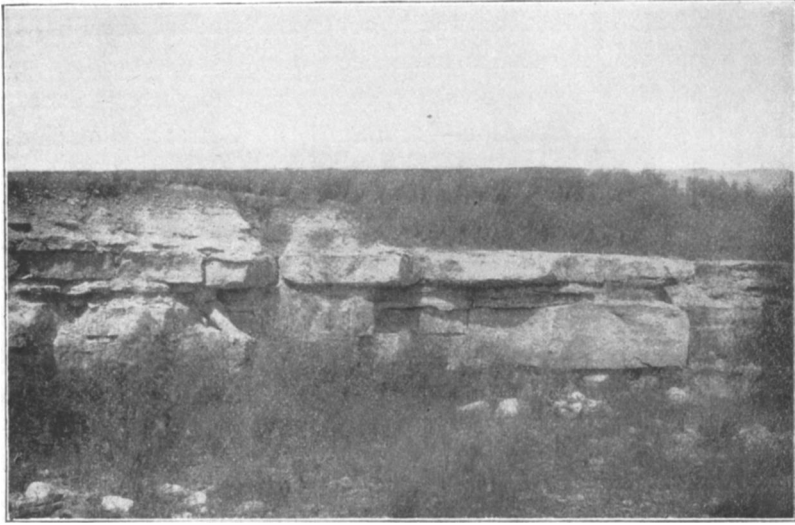
a = abundant; aa = very abundant; c = common; r = rare; rr = very rare, when but one or two specimens are found.

<sup>1</sup> See JOURNAL OF GEOLOGY, Vol. III, 1895, p. 766.



The Cottonwood limestone and the succeeding Nos. 3, 4 and 5 of this quarry are fairly well shown in Fig. 1.

The *Fusulina* limestone is filled with specimens of *Fusulina cylindrica* Fischer all the way through the massive stratum;



1. View of Cottonwood limestone just south of the Gilbert quarry, northwest of Auburn. The Cottonwood limestone is the heavy layer at the bottom. Then in ascending order are shown Nos. 2, 3 and 4 of the section.

but as in the Nemaha county quarry both Nos. 1 and 2 are regarded as representing the Cottonwood limestone of Kansas. The base of this quarry is forty feet higher than that of the Nemaha county quarry or approximately 405 feet above the Missouri River. Since it is two and one-half miles northwest of the Nemaha county quarry it gives between the two a dip of sixteen feet per mile to the southeast.

In a small run a quarter of a mile north of the Gilbert quarry and some seventy feet lower, the outcrop shows a ledge of light gray to buff rather hard limestone with shaly layers above and below. Fossils are few. *Aviculopecten occidentalis* (Shum.) M. & W. and *Cythere nebrascensis* Geinitz (?) occur in the shaly

layers and in some of them are large numbers of this minute Crustacean or a closely related species.

The *Carlisle quarry* is located on the northern edge of the rather steep bluff some distance south of the Nemaha River. It is nearly one mile north of the Gilbert quarry, and six miles west and 3 + miles north of Auburn. This is at the northern edge of the upland south of the Nemaha River and the farthest north that the Cottonwood limestone was found. In this quarry the base of the Cottonwood stone is about twenty feet higher than in the Gilbert quarry. The section of the G. W. Carlisle quarry is as follows:

		Feet	Feet
4. Shaly limestone	- - - - -	1 ½	= 7 ¼
3. Massive limestone	- - - - -	2	= 5 ¾
2. Shale	- - - - -	1 ¼	= 3 ¾
1. Cottonwood limestone.	Bottom of quarry - - -	2 ½	= 2 ½

Below the Cottonwood stone on the slope of the hill are thin ledges of smooth limestone alternating with shales. There is one stratum of limestone which on a weathered surface is rough and cellular something like the "dry bone" limestone in Kansas. There are also some reddish shales and the rocks, which for sixty feet below the Cottonwood limestone are partly exposed, resemble to some extent the upper rocks of the Wabaunsee formation in Kansas. These rocks are somewhat fossiliferous and in a bluish-gray shaly limestone from twenty to thirty feet below the Cottonwood limestone the following species were collected:

*Aviculopecten occidentalis* (Shum.) M. & W. (r).

*Pleurophorus subcostatus* M. & W. (?) Two rather large specimens which resemble the figures of this species quite closely (rr).

*Allorisma (Sedgwickia) cf. topekaensis* (Shum.) (Meek) (rr).

*Edmondia* sp. (rr).

*Bellerophon* sp. (rr).

In the region west of Auburn the highest rock found in place is the Cottonwood limestone with the shaly limestones immediately on top. The country to the west of the Nemaha county quarry rises from 100 to 125 feet higher, but a somewhat hasty search failed to reveal any ledges of rock in place, all being

quite deeply covered by drift and loess. On this high country seven and one-fourth miles west and one mile north of Auburn is a Burlington and Missouri River R. R. cut of ten feet which only shows the recent deposits, so that it would appear to be a difficult undertaking to find the bed rock on the uplands. This difficulty was experienced by Dr. Hayden who stated that: "From Tecumseh [the county seat of Johnson county, twenty-two miles west of Auburn] to the source of the Nemaha, about forty-five miles, I did not discover a single exposure of rock, and I could not ascertain that any had ever been observed by the settlers."<sup>1</sup>

From the facts stated above it seems reasonably certain that the massive limestone west of Auburn may be correlated with the Cottonwood limestone of Kansas. Lack of time prevented the actual tracing of this limestone south to the exposures of Cottonwood limestone in northern Kansas, yet its biologic and lithologic characters are so similar to those of the Kansas stone that it appears quite certain they belong to the same formation. In Kansas, the Cottonwood limestone is reported by Professor Knerr in the northeastern part of Marshall county where he states that it "disappears under the drift about five miles north of Beattie in Marshall county."<sup>2</sup> This locality is about fifty miles southwest of the Nemaha county quarry of Cottonwood limestone in Nebraska.

#### JOHNSON AND GAGE COUNTIES.

*Wabaunsee formation.*—Johnson county lies directly west of Nemaha county to the west of which is Gage county which extends south to the state line and is crossed by the Big Blue River. At Tecumseh in Johnson county about fifteen miles west of the Nemaha county quarry and from 100 to 200 feet lower, as far as I can judge from the data at hand, Dr. Hayden reported a

<sup>1</sup> Fin. Rep. U. S. Geol. Sur. Nebraska, p. 34.

<sup>2</sup> Univ. Geol. Sur. Kansas, Vol. I, 1896, p. 142. Also see "A Geologic Map of Kansas (preliminary)," Pl. XXXI, in the above work on which the line of outcrop of the Cottonwood limestone is represented.

stratum of coal from ten to fifteen inches in thickness.<sup>1</sup> In this connection it is interesting to state that Professor Knerr noted the occurrence of "a shale bearing a four-inch stratum of coal" which is given as from 50 to 100 feet below the Cottonwood limestone.<sup>2</sup> Again, in the vicinity of Tecumseh Dr. Hayden stated that "in a bed of limestone, holding a high position in the hills, the following fossils were found: *Spirifer cameratus*, *Athyris subtilita*, *Syntrilasma hemiplicata* [*Entelestes hemiplicatus*], *Productus semireticulatus*."<sup>3</sup> In Kansas, where the writer has carefully studied the stratigraphy and palæontology of the Upper Carboniferous and Permian rocks along the Kansas and Cottonwood valleys where they, as far as known, are more clearly exposed than at any other locality in the two states, *Spirifer cameratus* Morton has not been found above the top of the Wabaunsee formation, and from this fact the writer is inclined to refer the limestone mentioned by Dr. Hayden to the Wabaunsee formation.

*Permian.*—In Gage county, which lies next west of Johnson county, Dr. Hayden reported grayish and yellowish argillaceous limestones which he stated—"are undoubtedly of Permian or Permo-Carboniferous age, though they contain fossils common to both Permian and Carboniferous rocks."<sup>4</sup> He was not confident of the presence of Permian rocks in Nebraska for he said: "It is not certain that the true Permian beds, as recognized in Kansas, extend northward into Nebraska, though thin beds may occur in some of the southern counties."<sup>5</sup> And he further said that the Permian rocks "pass beneath the water level at Beatrice," the county seat of Gage county, and westward are the yellowish and dark brown Cretaceous sandstones, now known as the Dakota sandstone.

In 1886 Professor Hicks published a short paper about the rocks along the Blue River in Gage county which he designated provisionally as Permian and said that they were "distinguished

<sup>1</sup> Fin. Rep. U. S. Geol. Sur. Nebraska, p. 34.

<sup>4</sup> *Ibid.*, p. 28.

<sup>2</sup> Univ. Geol. Sur. Kansas, p. 142.

<sup>5</sup> *Ibid.*, p. 28, footnote.

<sup>3</sup> Fin. Rep. U. S. Geol. Sur. Nebraska, p. 34.

from the underlying Coal Measures by the absence of coal and black shales, and by the prevailing magnesian character of its limestones, by the presence of certain characteristic indurated marls and oölitic limestone, as well as by the new and distinct types of animal life.”<sup>1</sup> These rocks are undoubtedly of Permian age and it is probable that the Neosho formation and possibly a part of the Chase occurs in Gage county. This supposition is supported by the statement of Professor Knerr that in Marshall county, Kansas, which adjoins Gage county on the south, there are about 250 feet of Permian above the Cottonwood limestone.<sup>2</sup>

#### OTOE COUNTY.

##### HISTORIC REVIEW OF THE GEOLOGY OF THE COUNTY.

To the north of Nemaha and Johnson counties is Otoe county which extends from the Missouri River on the east to Lancaster county on the west. This is an important county in the history of the geology of southeastern Nebraska because the cliffs near Nebraska City have been fully described by several geologists.

Owen in 1852 gave some account of the rocks along this part of the Missouri River, referring them to the Carboniferous. He briefly described the rocks in the bluff near Fort Kearney (the old name for Nebraska City) and reported *Productus costatus*, *P. Flemingii* = *P. cora*, and *Fusulina cylindrica*, which he says “previous to this discovery was only known in Ohio.”<sup>3</sup>

Swallow in 1855 mentions strata at Fort Kearney and the mouth of the Little Nemaha which he referred to the “Upper Coal Series” of the Upper Carboniferous.<sup>4</sup>

In 1855 Marcou published a geological map of the United States on which the rocks along the Missouri River from the mouth of the Big Sioux to that of the Kansas River are colored

<sup>1</sup> Am. Naturalist, Vol. XX, p. 882.

<sup>2</sup> Univ. Geol. Sur. Kansas, Vol. I, p. 144.

<sup>3</sup> Rep. Geol. Sur. Wisconsin, Iowa and Minnesota, pp. 133, 134. See sections 34 and 35 M.

<sup>4</sup> 1st. and 2d. Ann. Rep. Geol. Sur. Missouri, p. 79.

as belonging to the "Terrain du nouveau Grès rouge" (Triassic system.)<sup>1</sup>

Marcou republished this map as a frontispiece of his *Geology of North America*, in which occurs the statement that "beds of *New Red Sandstone* . . . cover and form the majority of the immense prairies bordering the rivers Missouri, Platte, Arkansas, and Red River of Louisiana."<sup>2</sup>

In 1857 Dr. Hayden published a geological map of Nebraska on which the rocks along the Missouri River valley from about fifty miles north of the mouth of the Platte River, south to the Kansas River in Kansas, are colored as belonging to the Carboniferous age.<sup>3</sup> The following year Dr. Hayden published a second edition of the above map on which the Carboniferous area remains about the same. To the west of the Carboniferous, the Permian system, which was not indicated on the earlier map, is mapped. This system is represented as beginning at a point a number of miles northwest of Nebraska City and then extending southward increasing in breadth to the southern part of Kansas. The base of the system is represented as crossing the Republican and Smoky Hill rivers several miles west of Ft. Riley, while its upper boundary crosses the Grand Saline and Smoky Hill rivers a number of miles west of the present city of Salina. In Kansas, small areas of Permian are represented on the high divides to the east of the main Permian area. Immediately west of the Permian or the Carboniferous where the Permian is absent, rocks are represented that are referred to the Lower Cretaceous.<sup>4</sup>

In 1863 Marcou and Capellini studied the Missouri River section along the eastern border of Nebraska and the following January Marcou published quite a full description of the rocks

<sup>1</sup> Carte Géologique des Etats-Unis et des Provinces Anglaises de l'Amérique du Nord. In Bull. Soc. Geol. France, Vol. XII.

<sup>2</sup> Op. cit., Zurich, 1858, p. 11.

<sup>3</sup> Proc. Acad. Nat. Sci., Philadelphia, Vol. IX, opposite p. 109 and on p. 110 the description of the area of the system.

<sup>4</sup> *Ibid.*, Vol. X, p. 139. For a statement of the distribution of the Permian, see p. 144.

in the vicinity of Nebraska City and referred them to the Upper Dyas or Permian.<sup>1</sup>

The following year Meek criticised the correlations of this paper, stating that "all the rocks seen by Mr. Marcou on the Missouri, from St. Joseph to the Cretaceous above Bellevue, belong to one unbroken series of Upper Coal Measures, as was first shown by Professor Swallow; with possibly the exception of some of the highest outcrops near Nebraska City, where there is a downward undulation, that may have left portions of the Permian on the high parts of the country."<sup>2</sup>

In 1866 Geinitz described the fossils collected by Marcou in Nebraska together with some from the Permian of Kansas,<sup>3</sup> and also concluded that the rocks in the vicinity of Nebraska City belonged to the Dyas.<sup>4</sup>

Meek in 1867, reviewing at length Professor Geinitz's work, failed to agree with him in many instances concerning the identity of Nebraska species with those of Europe;<sup>5</sup> he also reaffirmed his previous statement that the Nebraska City rocks with possibly the exception of the highest beds, belonged in the Upper Coal Measures.<sup>6</sup>

<sup>1</sup> Bull. Soc. Géol. France, 2<sup>e</sup> sér. Jan. 1864, Vol. XXI, pp.134-137. Marcou's conclusion, based on the fossils he collected being expressed as follows: "Les fossiles que j'ai trouvés dans cette section [Nebraska City] m'ont rappelé tout à fait le faune dyasique du Zechstein de la Saxe, et je regarde ces couches de Nebraska-City comme appartenant et représentant en Amérique la partie supérieure du dyas d'Europe," p. 137.

<sup>2</sup> Am. Jour. Sci., 2d ser., Vol. XXXIX., March 1865, p. 165.

<sup>3</sup> M. d. K. Leop.-Carol. Akad. d. Naturl.—Carbonformation und Dyas in Nebraska. Dresden, pp. vii+91. 5 plates.

<sup>4</sup> *Ibid.*, p. 89, where he says: "Die bei Nebraska-City vorkommenden Versteinerungen gehören einer Zone an, welche den untersten bis mittelren Schichten der deutschen Zechsteinformation (oberen Dyas) entspricht."

<sup>5</sup> Am. Jour. Sci., 2d ser., Vol. XLIV, Sept. 1867, pp. 170-188; Nov., pp. 327-340.

<sup>6</sup> Meek's statement was as follows: Those [rocks] by both of them [Marcou and Geinitz] referred to the Upper Dyas at Wyoming and Bennett's Mill and Nebraska City, with *possibly* the exception of divisions C and D [the higher beds] at the latter place, belong to the horizon of the Upper Coal Measures. The only point in regard to which there can be any reasonable doubt is, whether the divisions C and D at Nebraska City belong more properly to the horizon of the rocks Dr. Hayden and I termed Permo-Carboniferous in Kansas, or to the Coal Measures proper." (*Ibid.*, pp. 336-337.)

In 1868 Professor Marcou reaffirmed the Dyassic age of the Nebraska City rocks, stating that: "In Nebraska the Dyassic rocks form the right bank of the Missouri River from Aspinwall to Plattsmouth and Aureopolis, that is to say, all the bluffs of the counties of Nemaha, Otoe, and Cass. . . . The best section of the Dyas of Nebraska and the most easy to be studied, is that formed by the bluff at the Nebraska City landing, at Otoe City, at Peru, and at Brownville, where the strata are higher in the Dyassic series than at Nebraska City; whilst at Rock Bluff, Plattsmouth, and Aureopolis, on the contrary, we find the lower layers forming the base of the Nebraska Dyas."<sup>1</sup> Following the above is a detailed section of the rocks at the Nebraska City landing accompanied by lists of fossils which were identified by Professor H. B. Geinitz. In 1892 Professor Marcou still regarded the Nebraska City rocks as of Lower Dyassic age.<sup>2</sup>

In the summer of 1867 Meek and Hayden spent about two months in carefully studying the rocks along the Missouri River from Omaha to Kansas. In 1872 an excellent work based upon this study was published in which Hayden discussed the general geology of southeastern Nebraska, and Meek gave a detailed account of the stratigraphy of the Missouri River region accompanied by a very careful description of the fossils.<sup>3</sup> This work has become a classic in palæontology for the Upper Carboniferous of the Mississippi Valley. The conclusion in reference to the age of these Missouri River beds agrees with the former opinion of Meek and is clearly expressed in the following sentences: "From all of the facts, therefore, now determined, it must, I think, be clearly evident that all of these strata under consideration along the Missouri, that have been by some referred in part to the Mountain limestone, in part to the Permian or Dyas, and in part to the Coal Measures, really belong entirely to the true Coal Measures; unless the division C, at

<sup>1</sup>Trans. Acad. Sci., St. Louis, Vol. II, p. 562.

<sup>2</sup>Am. Geol., Vol. X, pp. 369, 373.

<sup>3</sup>Final Rep. U. S. Geo. Sur. Nebraska and portions of the adjacent Territories, pp 245, 11 plates.



Nebraska City, and some apparently higher beds below there on the Missouri, may possibly belong to the horizon of an intermediate series between the Permian and Carboniferous, for which, in Kansas, Dr. Hayden and the writer proposed the name *Permo-Carboniferous*. . . . It is true that in first announcing the existence of Permian rocks in Kansas, we also, upon the evidence of a few fossils from near Otoe and Nebraska cities, resembling Permian forms, referred these beds to the Permian; but on afterwards finding that these fossils are there directly associated with a great preponderance of unquestionable Carboniferous species; and that there is also in Kansas a considerable thickness of rocks between the Permian and Upper Coal Measures containing, along with comparatively few Permian types, numerous unmistakable Carboniferous forms, we abandoned the idea of including these Otoe and Nebraska City beds in the Permian. And all subsequent investigations have but served to convince us of the accuracy of the latter conclusion."<sup>1</sup>

It is to be noted in reference to this correlation of the Upper Palæozoic rocks of Nebraska with the Upper Coal Measures, that Meek did not intend to include the rocks in Kansas which he and Hayden had called Permian,<sup>2</sup> a fact which has been misapprehended by certain writers on the geology of this region. Since the report of Meek and Hayden, no contribution of importance has appeared relating to the geology of the Upper Palæozoic of Nebraska, consequently it is especially interesting to compare their conclusions with our present knowledge which has been enriched by the labors of the last quarter of a century.

CHARLES S. PROSSER.

<sup>1</sup> Fin. Rep. U. S. Geol. Sur. Nebraska, etc., pp. 130, 131.

<sup>2</sup> Trans. Albany Inst., Vol. IV, 1858, p. 76; Proc. Acad. Sci. Phil., Vol. XI, 1859, pp. 20, 21; and Am. Jour. Sci., 2d ser., Vol. XLIV, 1867, p. 37.